

Hazard Mapping and Modeling

INTRODUCTION

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What Are Hazards?

- The most concise definition of the term “hazard”:
- Hazards are “threats to humans and what they value”.
 - (Kates, et al, 1985 in *Perilous Progress*)

What Are Hazards?

“What they value” was defined by Kates in 1985 in *Perilous Progress*.

It includes: life, well being, material goods and environment.

In *Multihazard Identification and Assessment* FEMA defines hazards as:

“Events or physical conditions that have the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss.”

***Webster's Dictionary* defines a hazard as:**

“a source of danger;
a chance event;
an accident, etc.”

The Role of the Term “Hazard”

The term “hazard” is descriptive.

It describes with words.

The Role of the Term “Risk”

The term “risk” calculates or measures with a mathematical formula the likelihood that adverse consequences will result from a hazardous event.

$$\text{RISK} = \text{LIKELIHOOD} \times \text{CONSEQUENCES}$$

_What is a “Disaster”?

More than 100 people dead or injured and more than 1 million US \$ in damages

(Burton *et al*, 1978).

“Hazard” represents *potential* events while “disasters” result from *actual* events involving humans.

THE UNIVERSE OF HAZARDS

THE ENVIRONMENT

GEOPHYSICAL EVENTS

EXTREME GEOPHYSICAL EVENT NATURAL HAZARDS

INTENSIVE

Avalanche
Earthquake
Flash Flood
Frost
Hail
Lightning
Tornado
Tsunami
Volcano
Wildfires

PERVASIVE

COASTAL EROSION
DESERTIFICATION
DROUGHT
FLOOD
SOIL EROSION

COMBINED

EXPANSIVE SOILS
HURRICANE
LAND SUBSIDENCE
LANDSLIDE

TECHNOLOGY

RELEASE OF ENERGY, MATERIAL, OR INFO TECHNOLOGICAL HAZARDS

MULTIPLE EXTREME HAZARDS

ACTS OF TERRORISM (INTERNATIONAL)
NUCLEAR WAR
RECOMINANT DNA
PESTICIDES
NERVE GAS - WAR US
DAM FAILURE

EXTREME HAZARDS

INTERNATIONAL BIOCIDES (ANTIBIOTICS, VACCINES)
PERSISTENT TERATOGENS (URANIUM MINING, RUBBER MANUFACTURE)
RARE CATASTROPHES (LNG EXPLOSIONS, COMMERCIAL AVIATION CRASHES)
COMMON KILLERS (AUTOMOBILE CRASHES, COAL MINING - BLACK LUNG)
DIFFUSE GLOBAL THREATS (FOSSIL FUEL - CO₂ RELEASE, SST OZONE DEPLETION)

HAZARDS

SACCHARIN
ASPIRIN
BICYCLES

Technological Hazard Definitions

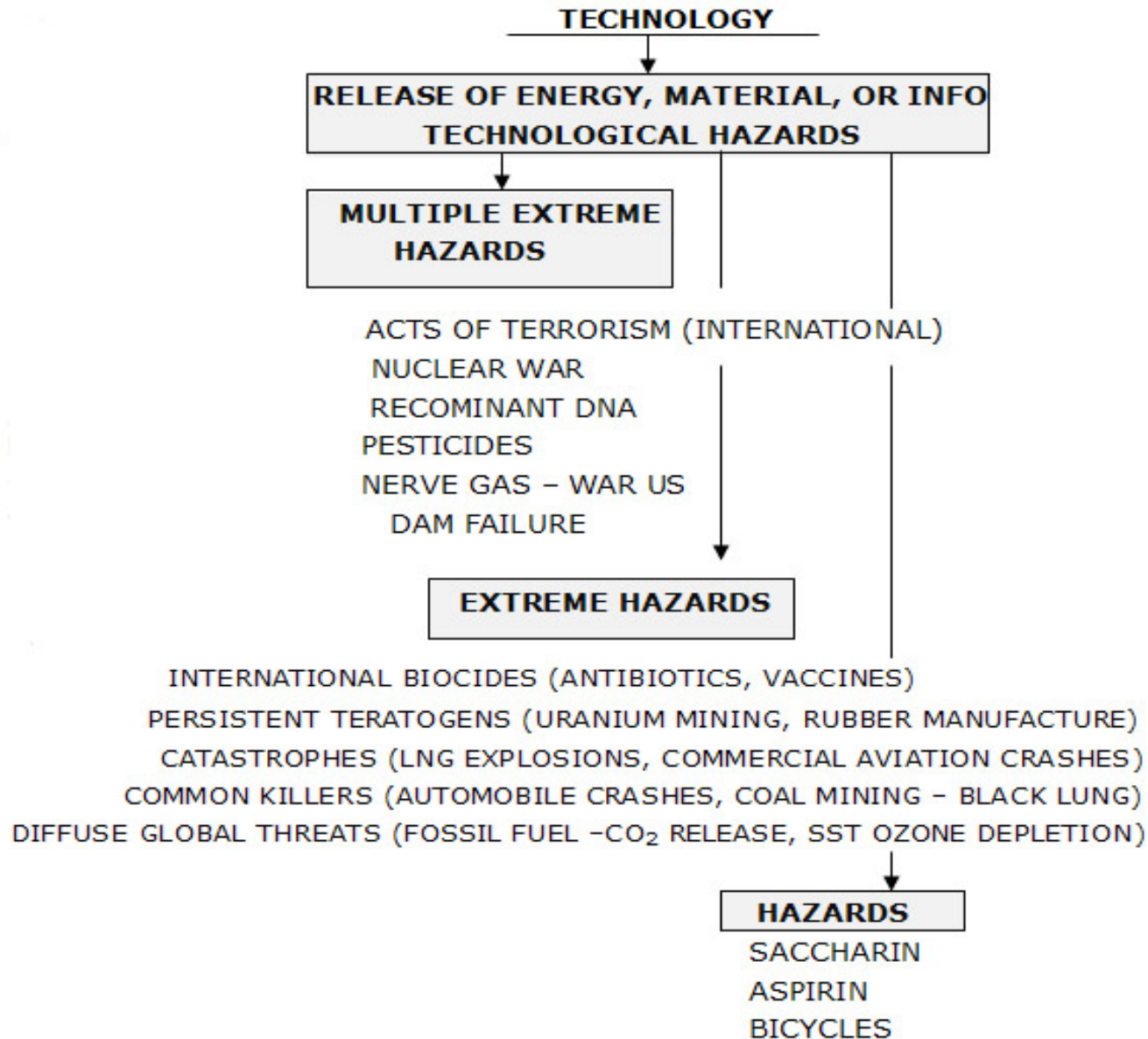
biocide:

a substance (such as DDT) that is toxic to many different organisms

teratogen:

an agent that tends to cause developmental malformations or monstrosities in the next generation

Research Classifications for Technological Hazards



FEMA'S CLASSES FOR TECHNOLOGICAL HAZARDS

Dam Failures

Fires

Hazardous Materials Events

Nuclear Accidents

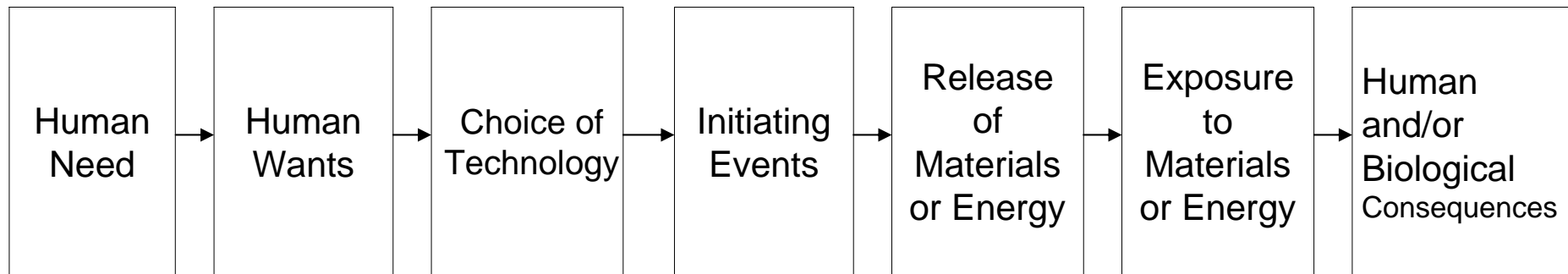
National Security Hazards

Power Failures

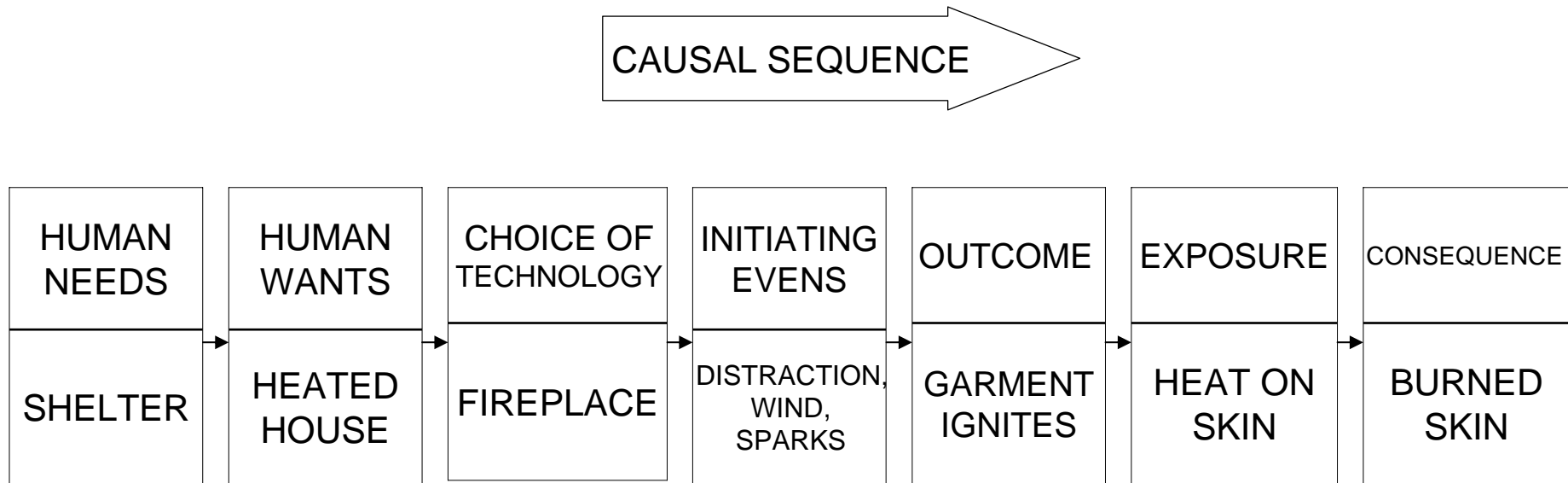
Telecommunications Failures

Causal Model of Technological Hazards

CAUSAL SEQUENCE OF HAZARD →

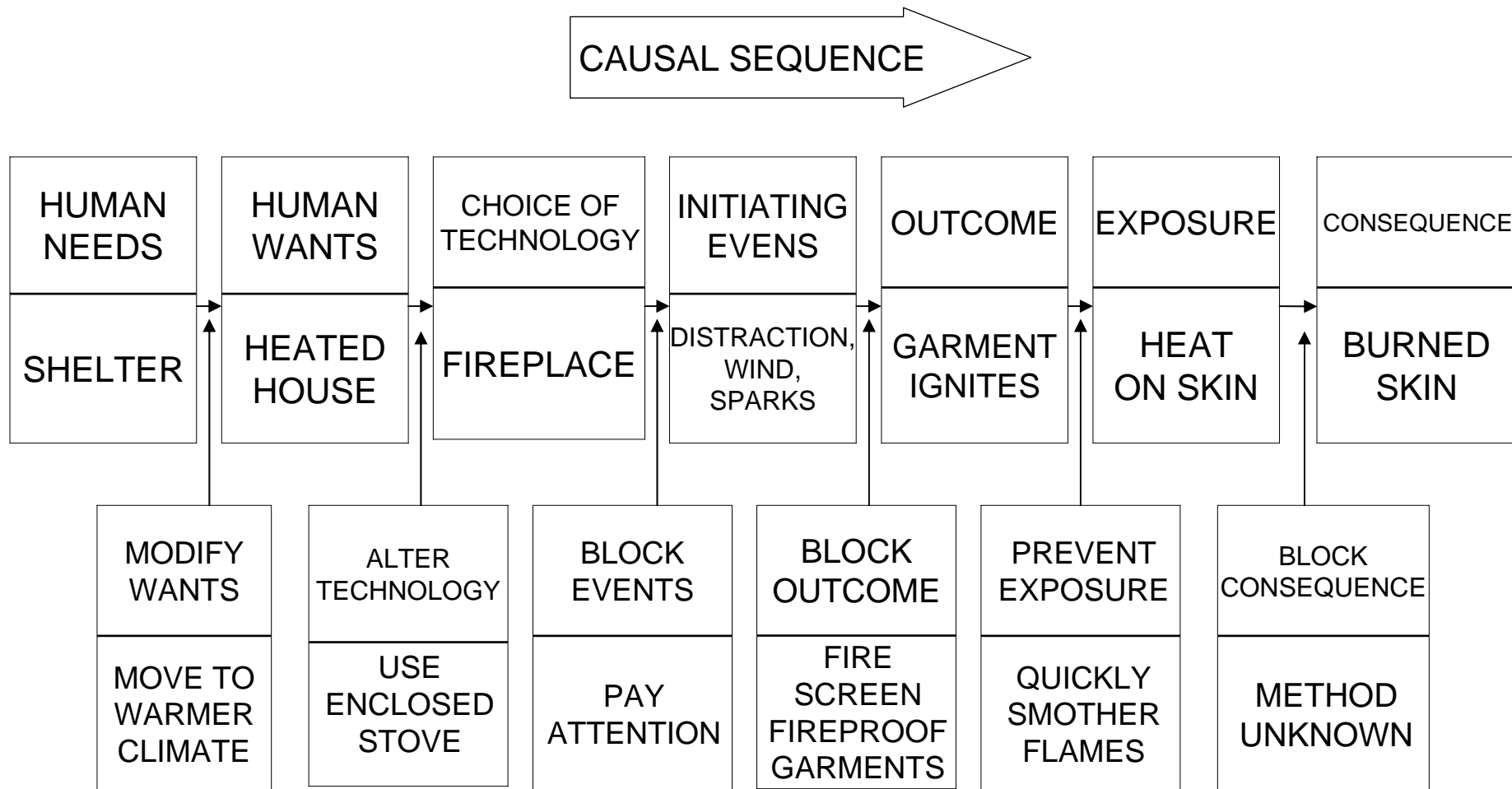


CAUSAL SEQUENCE FOR BODILY HARM FROM A FIREPLACE HAZARD



Seven-stage hazard sequence, illustrated here for the case of the fireplace.

CONTROL INTERVENTIONS FOR A FIREPLACE HAZARD



Seven-stage expansion of the hazard sequence, illustrated here for the case of the fireplace. Note the range of possible control interventions

INTERVENTION = MITIGATION

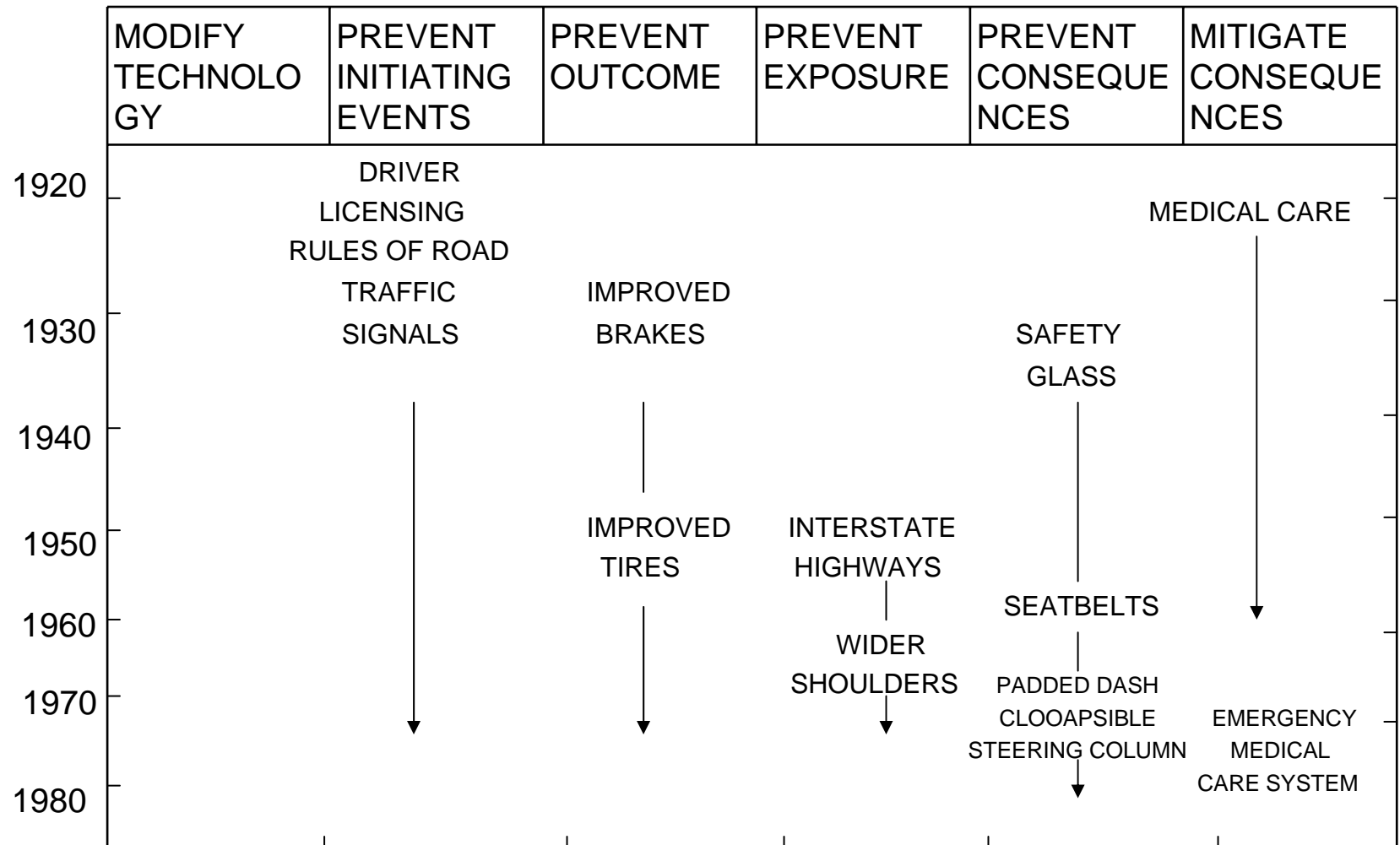
Intervention at this individual level is akin to mitigation efforts by society.

Mitigation is the effort to reduce the impact of an actual or potential disaster.

Mitigation can broadly be divided into structural and nonstructural forms.

INTERVENTIONS TO CONTROL AUTOMOBILE HAZARDS

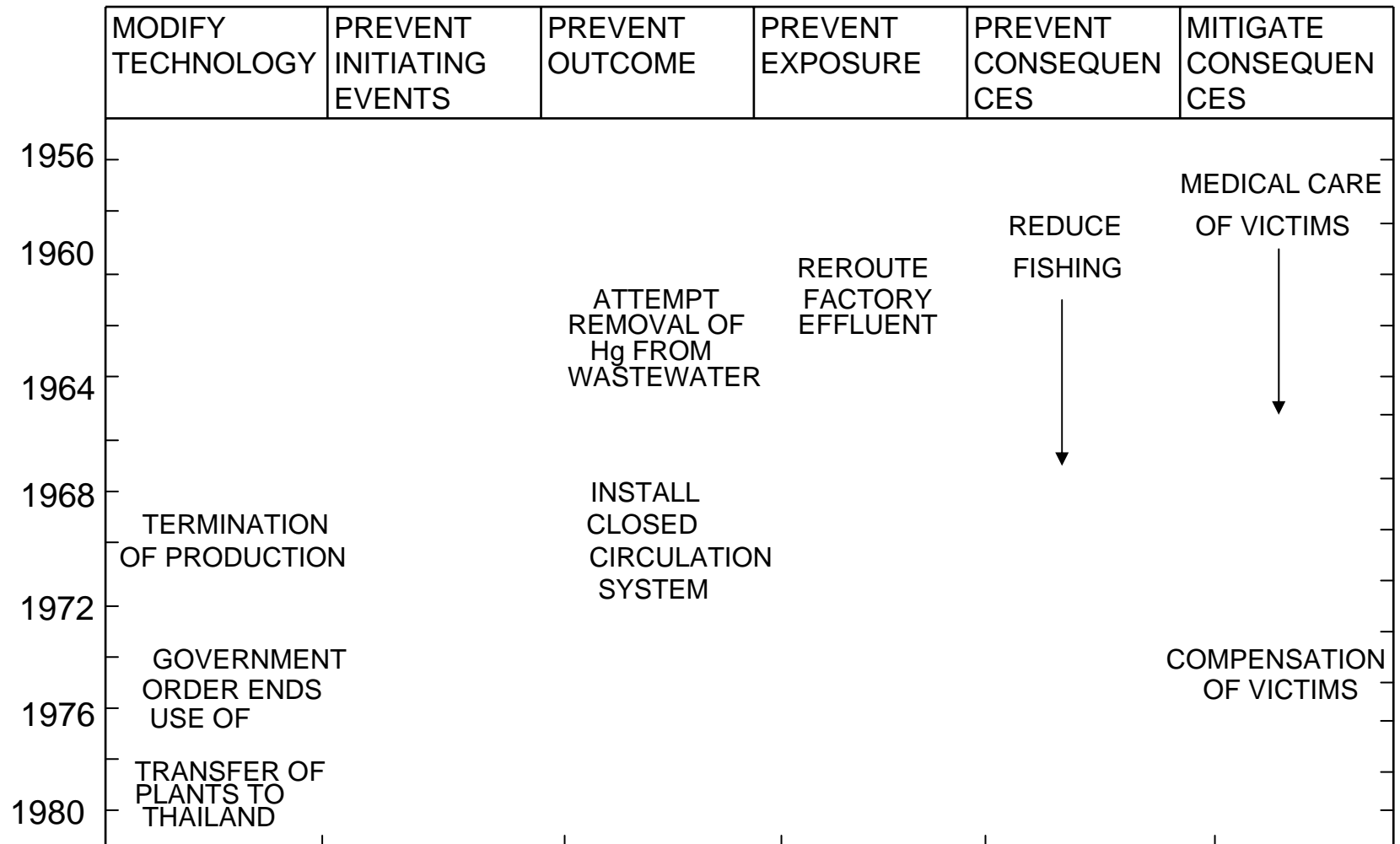
1920 -1980



Chronological distribution of hazard control intervention by hazard stage for the case of automobile safety

Source: Kates, et al, 1985 in *Perilous Progress*

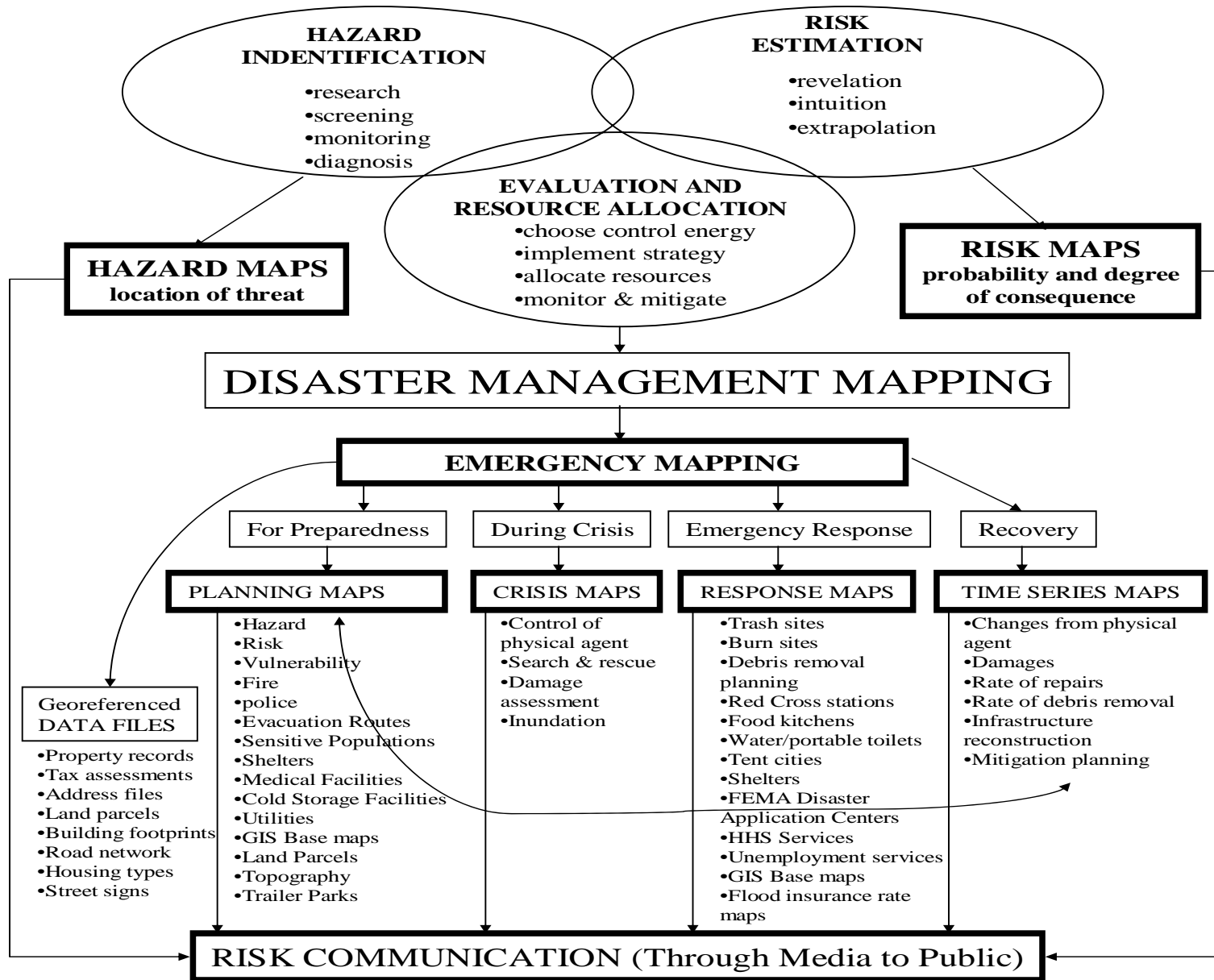
CHRONOLOGY OF HAZARD CONTROL FOR MINIMATA DISEASE 1956-1980



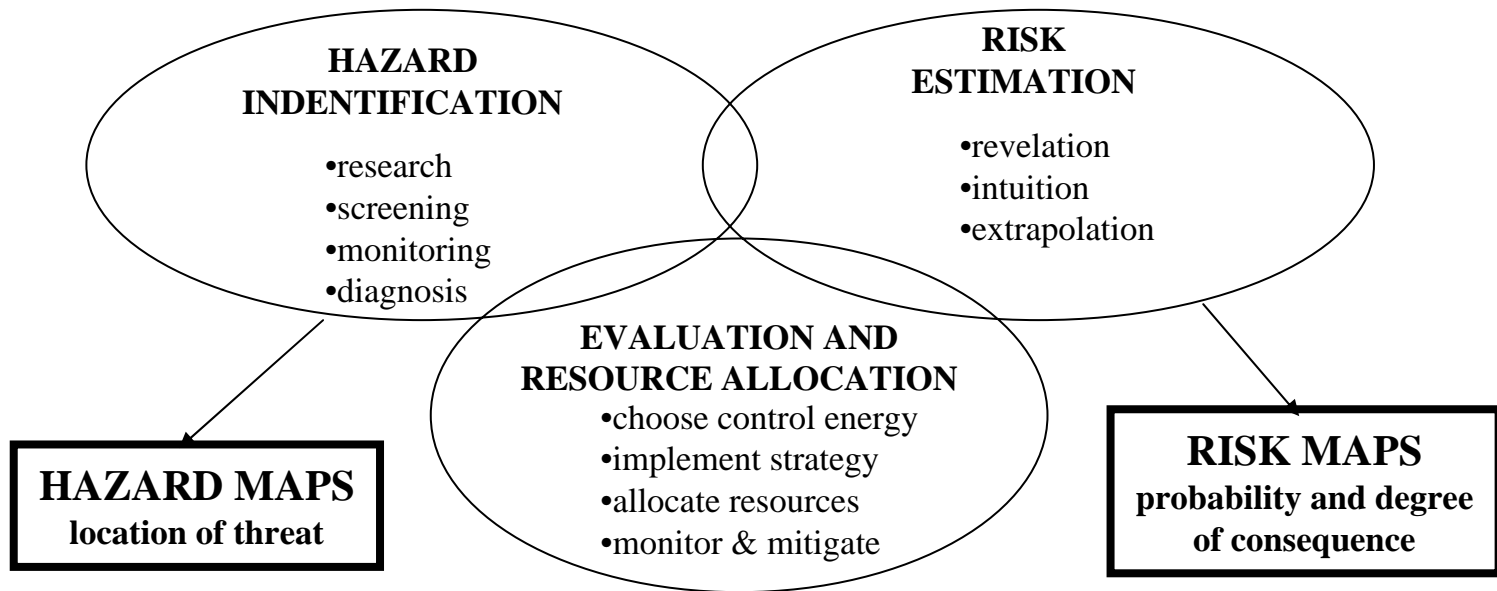
Chronological distribution of hazard control intervention by hazard stage for a case of Minamata disease

Source: Kates, et al, 1985 in *Perilous Progress*

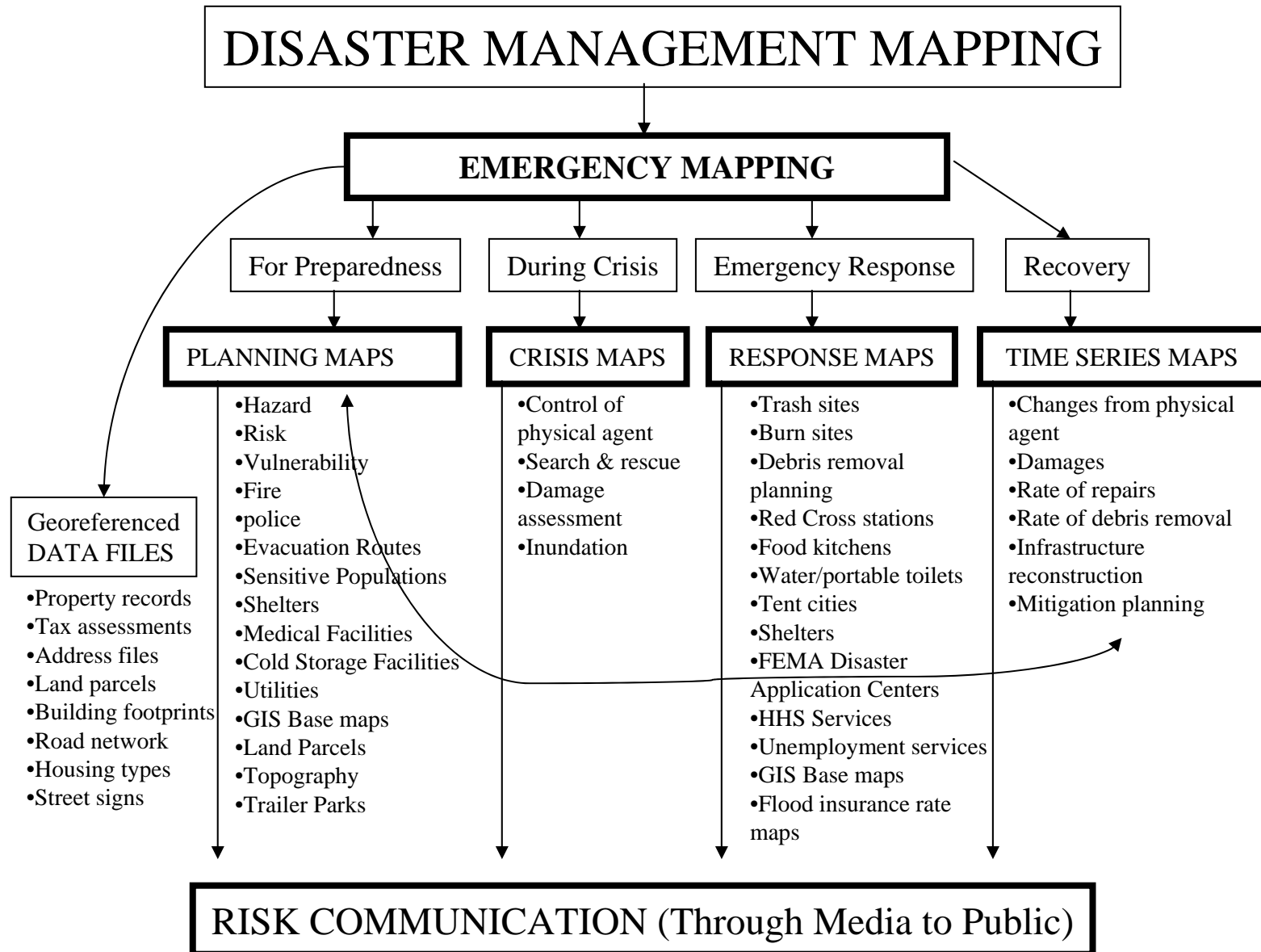
THE HAZARD MANAGEMENT MAPPING MODEL



HAZARD ASSESSMENT PORTION OF THE HAZARD MANAGEMENT MAPPING MODEL



EMERGENCY MANAGEMENT PORTION OF THE HAZARD MANAGEMENT MAPPING MODEL



BASIC ROLES MAPS PLAY IN EMERGENCY MANAGEMENT

- 1. Facilitate resource/service flow before/during /after emergency.**
- 2. Coordinate efforts of emergency groups and services by use of a concreted model.**
- 3. Concrete model/guide for public action.**
- 4. Quick tracking of key information ---at a glance.**

PITFALLS IN PROVIDING EMERGENCY MAPS TO THE PUBLIC

1. how to distribute so there's availability
2. how to keep maps up-to-date and available after updating
3. what information to include
 - This requires assumptions to be made about a.) what level of education the user (the public) will have, especially about technical issues, b.) reading ability levels and map reading skills
4. how technically trained is the public in map reading and use
5. how to incorporate local knowledge – often this can't be put on the map but needs to be considered when doing the planning for emergency (this is one of the most problematic areas of emergency map design)

DEFINITION FOR *FREQUENCY*

Frequency is the temporal distribution of extreme geophysical events (natural hazards) and their recurrence intervals or return periods.

Some physical processes can be delineated within seasonal or diurnal time periods.

Duration means a temporal period ranging from seconds to years.

DEFINITION FOR *MAGNITUDE*

The magnitude of a geophysical event is determined by scientific measures of the strength of the physical event.

“Measures of magnitude do not concern impacts of an event on the human-use system, that is **intensity**, but rather the physical processes involved.” (Tobin, Graham A. and Burrell E. Montz. 1997. *Natural Hazards*. New York: Guilford Press. 53.)

Direct measurements of some hazards are difficult to make; in these cases *intensity* ratings that indicate degrees of destruction of the built environment are applied.

The **Modified Mercalli scale** for earthquakes and the **Fujita scale** for tornadoes include building damage to show magnitude.

DEFINITION FOR *VULNERABILITY*

Vulnerability means how susceptible or how resilient a society is to negative consequences from hazards, or how much risk exists in that society.

Identifying what characteristics of the society - physical, social, economic - make it more, or less, resilient to hazardous events helps clarify the society's vulnerability.

(Cutter, Susan L. 1994. *Environmental Risks and Hazards*. Englewood Cliffs NJ: Prentice Hall)

What is ADJUSTMENT?

Human actions to minimize the threat of a natural hazard and to mitigate its effects.

These actions give the society the capacity to absorb the extreme natural event.

Three major types of adjustment can take place in a community:

- **MODIFY THE EVENT** by structural responses that control the event or the damage it causes.
- **SHARE THE LOSS BURDEN** by spreading the financial burden by hazard insurance or relief.
- **MODIFY THE HUMAN-USE SYSTEM** to reduce losses by forecasting, warning systems, preparedness plans, evacuation plans, better building design, etc.

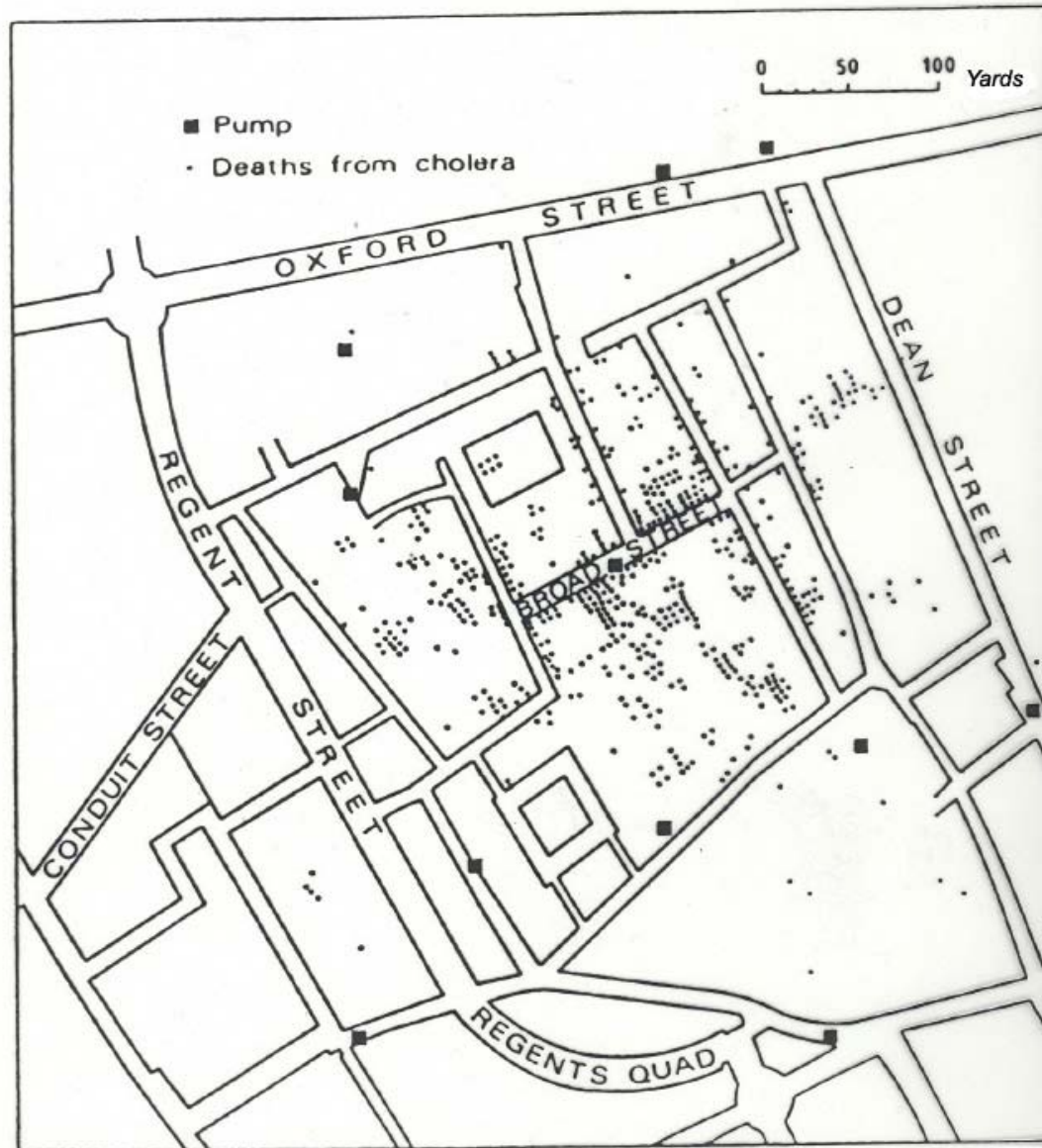
(Cutter, Susan L. 1994. *Environmental Risks and Hazards*. Englewood Cliffs NJ: Prentice Hall)

DEFINITION OF *CRISIS MAPPING*

Crisis maps are made on-the-spot, often with crude materials, during the peak danger time of an emergency to control the physical agent causing the destruction or to control its consequences.

(Dymon, Ute J. and Nancy L. Winter. 1991. Emergency Mapping in Grassroots America: A Derailment Evacuation Case Study. *Geoforum*. 22:4 377-389.)

DR. JOHN SNOW'S MAP OF A WATER-BORNE CHOLERA SOURCE



DEFINITION OF EPIDEMIOLOGY

The study of epidemics, their origins, causes and vectors (methods or paths of transmission of a disease.)

TIMELINE OF LEGISLATION THAT SPURRED HAZARD MAPPING

- 1966 Disaster Relief Act enacted
- 1969 National Flood Insurance Program (NFIP) established
- 1970 National Environmental Protection Act (NEPA) enacted
- 1970 Environmental Protection Agency (EPA) created
- 1972 Clean Water Act amended
- 1977 National Earthquake Hazard Reduction Program (NEHRP) enacted
- 1977 Executive Order #11988 Floodplain Management
- 1977 Executive Order #11990 Protection of Wetlands
- 1979 Executive Order #12148 Federal Emergency Management: FEMA created
- 1981 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA- Superfund) enacted
- 1986 Emergency Planning and Community Right to Know Act of 1986, also known as SARA Title III
- 1991 Amendments to the 1955 Air Pollution Control Act,
- 1996 Weapons of Mass Destruction (Nunn-Lugar-Domenici Act) enacted
- 2003 Homeland Security Act